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TENTATIVE SANITARY STANDARDS AND REGULATIONS FOR RESTRICTING NOISE IN INDUSTRY

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A. Tentative Standards for Permissible Noise Levels in Industry

Purpose and Areas of Application

1. The present standards establish values for permissible noise levels and spectra at operator posts in industry, and set forth basic requirements aiming at the prevention of professional illness among personnel working in noisy surroundings.

   Note. The permissible noise level values established hereby apply to the work day of normal duration.

2. The standards apply to industrial concerns, scientific research institutes and laboratory and testing facilities in which noise-producing equipment is in operation.

Permissible Levels of Noise in Industry

3. In accordance with their frequency ranges (spectra), all noises are divided into three categories: (1) low-frequency, (2) median-frequency and (3) high-frequency noises. For each of these categories, permissible levels are established (in decibels) in accordance with a graph (see Fig. 1) of permissible levels of noise* and Table 1.

   Note. Table 1 serves merely as an exemplification to the graph in Fig. 1, which provides the basis for accurate determinations of permissible noise levels.

Table 1

Permissible Levels of Noise in Industry for Noises of Various Categories**

Category and Description of Noises	Permissible Level in Decibels
Category 1 - Low-frequency noises (produced by non-percussive units of slow	

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* An explanation of the graph and indications for its use may be found in Appendix 3.

** Precise values for permissible noise values should be determined from the graph in Fig. 1.

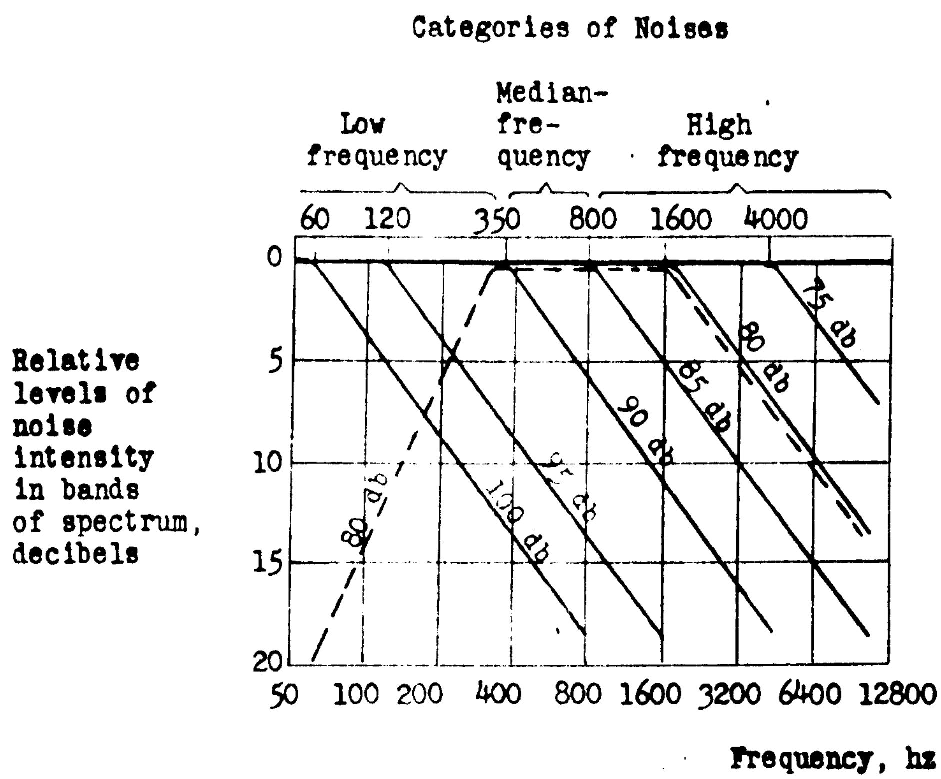

Fig. 1. **Permissible noise levels in industry for various categories of noise (graph of standards)**

Table 1 (con't)

		Permissible Level in Decibels
	operating speed, noises penetrating through sound-proofing barriers, such as walls, ceilings, casings), whose highest levels in the spectrum are situated below a frequency of 300 hz, above which levels become lower (by no less than 5 db per octave)	90-100
Category 2 -	Median-frequency noises (noises produced by most non-percussive machines, mills and plant units), whose highest levels in the spectrum are situated below a frequency of 800 hz, above which levels become lower (by no less than 5 db per octave)	85-90
Category 3 -	High-frequency noises (ringing, hissing and whistling sounds characteristic of percussive units, air and gas streams, and units operating at high speeds), whose highest levels in the spectrum are situated above a frequency of 800 hz	75-85

4. An additional obligatory requirement supplementing standards given for permissible levels and spectra is that of the non-obstruction of speech, which must be satisfied for noises of all three categories, namely: that speech at normal voice level be readily intelligible at a distance of 1.5 meters from the speaker*.

5. In non-noisy industrial accommodations, located on plant premises, such as engineering, clerical and administrative offices, the level of noise penetrating through closed doors and windows from other portions of the plant must not exceed 50 ph**, regardless of the frequency range of the noise. Stipulation in Para 4 does not apply to such offices.

6. Noise levels are measured by a correctly calibrated noise gage, while frequency spectra are measured with a noise gage connected to a band filter or analyzer (see Appendix 2).

Measures for the Prevention of Harmful Effect of Noise on Workers

7. If noise levels at operator posts exceed the standards hereby established, it is required that measures be taken to lower them to permissible values,

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* The method of evaluating adequate intelligibility of speech is described in greater detail in Appendix 4.

** Or 60 db, as measured in terms of the horizontal frequency rating of a sound gage.

by following the "Regulations for the Design and Operation of Plant Units and Buildings for the Purpose of Reducing Noise in Industrial Plants" given below (see Section B).

8. In cases of the technical impossibility of lowering noise at operator posts to permissible volume, given the present state of industrial technology and sound-control techniques, it is required that a schedule of prophylactic measures be established to preserve the health of the workers by means of:

   (a) changes in the work and rest schedule by agreement with the All-Union Central Council of Trade Unions (ACCTU);

   (b) equipment of workers with individual means of protection (ear caps, helmets, ear plugs), which would not be irritating to the ear, while ensuring the deadening of sound to the permissible standard level.

9. Individuals being admitted to work, or who have been working in noise-producing industries, where the level of noise exceeds permissible standards, must be submitted to preliminary (upon hiring) and periodical (during work) medical examinations. These examinations must involve the participation of an otolaryngologist, who is to give an opinion regarding the individual's state of hearing on the basis of an audiogram and a test bearing on the individual's apperception of speech.

   Diseases of the organs of hearing, ulcerous or hypertonic conditions and neural diseases revealed by a preliminary medical examination must be considered as grounds for barring the individual from work under noise conditions exceeding permissible standards.

   Periodic medical examinations are to take place in accordance with the instructions issued by the Ministry of Health of the USSR.

   Individuals who, in the interval between two of the periodic medical examinations, have incurred substantial loss of hearing (over 20 db) or a marked deterioration of the general state of health of their organism, must be transferred to duties in which they are not exposed to noise.

10. The technical impossibility of lowering noise level must be established by a commission consisting of representatives of:

   (a) the Ministry or Main Administration responsible for the concern;

   (b) the Central or General Committee of the Trade-Union;

   (c) the Sanitation and Epidemiology Station.

11. The schedule of preventive measures, provided for under Paras. 7 and 8, is to be established in concrete form for each concern, in accordance with the specific conditions and nature of the noise, by the Ministry or Main Administration responsible for the concern, in cooperation with the Central or General Committee of the Trade-Union and the Sanitation and Epidemiology Station.

B. Regulations for the Design and Operation of Plant Units and Buildings for the Purpose of Reducing Noise in Industrial Plants

Purpose and Areas of Application

1. The present regulations contain requirements whose satisfaction ensures the reduction of noise at operator posts (in industrial plants) to the levels allowed by the standards.

2. The requirements of the present regulations apply to the design and manufacture of machines and plant units, as well as to the designing and construction of all industrial enterprises and scientific testing facilities.

3. The present regulations provide a basis for the preparation of recommendations for noise control under concrete conditions of operation in enterprises involved.

   Note. In operating industrial organizations, as well as in plants undergoing rebuilding, in cases when the observance of specific stipulations in the regulations hereinunder is impossible without extensive re-designing or wrecking of existing structures, it is permissible to depart from these stipulations upon agreement with the ACCTU and government health agencies.

Requirements of Design for the Reduction of Machine and Plant Unit Noise

4. In designing new machines and plant units, means must be sought to reduce their noise as much as possible and, in any event, to reduce noise at operator posts near the units to levels not exceeding those permissible, as indicated in Para 3 of Section A.

5. For purposes of reducing machine noise at its source, the following practices should be followed, insofar as possible:

   (a) replacing percussive operations by non-percussive ones;

   (b) replacing reciprocating motions of machine parts by rotary ones;

   (c) damping vibrations in parts and plant unit assemblies involved in impacts through the use of coupling materials of high viscosity, e.g., rubber, cork, bitumen, asphalt board and matting, asbestos;

   (d) reducing the intensity of vibration of unit parts having broad sound-generating surfaces (frames, casings, lids, etc.,) by:

   - lining or filling especially provided airspace within them with damping materials listed under sub (c) of this paragraph;

   - making use of flexible couplings (elastic stripping, springs) between these parts and areas where the vibrations originate;

(e) replacing metal parts by parts out of plastic or other noiseless materials, or interpose parts out of noiseless materials between metal parts;

(f) allowing for careful balance (static and dynamic) between all moving parts of the unit, so as to reduce the dynamic forces responsible for vibration;

(g) providing for close margins in the manufacture and assembly of unit parts to reduce free play between the assembled parts and thereby reduce the energy involved in shocks and the intensity of vibration and noise;

(h) providing for a procedure of assembly of unit parts reducing to a minimum inaccuracies in assembly (poor alignment, incorrect spacing of centers, etc.);

(i) making extensive use of lubrication of parts involved in impacts with viscous fluids, and the enclosure in oil and other baths of vibrating and noise-producing parts (reduction gears, etc.)

(j) replacing antifriction bearings with sleeve bearings in cases when bearings are responsible for most of the noise generated by the unit;

(k) limiting, insofar as possible, the velocity of flow of air and gas streams over unit parts (in ventilators, ejectors, blowers, etc.)

6. If the present state of technology makes it impossible to reduce noise at its source to permissible levels, this reduction must be accomplished through the inclusion in unit design of devices preventing the propagation of sound outward, i.e., devices insulating or absorbing sound. With this in view, it is necessary to:

(a) enclose noisy areas of the unit, such as reduction gears, chain, belt and other types of transmissions, moving parts subject to impacts, etc., in insulating casings;

(b) enclose plant units emitting sound over their entire surfaces (nail making machines, braiding machines, machines for watch jewel processing, diesel power units, electric motors, reduction gears, etc.) in sound-insulating casings entirely, providing outlets for controls and control instruments and, if possible, having the operation of the machine controlled automatically;

(c) design needed openings in the sound-proof casing in the form of ducts lined with sound-absorbing materials on their inner surfaces;

(d) provide special silencers for all plant units that generate undue noise through turbulence or air and gas release (ventilators, blowers, tools and machines using compressed air, pneumatic ejectors, internal combustion engines, etc.);

(e) install shock-absorbers in the form of springs or other elastic parts under plant units which are not designed to be supported by special foundations, and which operate on premises bordering on noiseless quarters (clerical or engineering offices, etc.), so as to prevent vibrations generated by the operation of these units to spread into adjoining areas in the form of noise.

7. The mandatory degree of machine silencing by means of sound-insulating devices and silencers is to be determined on the basis of stipulations listed in Appendix 5.

8. The technical permits of plant units put into production must specify noise levels created by the unit at the operator's post and at distances of 1 and 5 meters, as well as the sound spectrum at the operator's post and at a distance of 5 meters.

9. The noise level of mass produced models cannot exceed by more than 3 db the noise level of the most perfect prototypes of a given unit.

10. It is prohibited to carry out any improvement or re-modeling of equipment that leads to a substantial increase in the amount of noise generated (over and above standard levels), unless special measures are taken to reduce noise.

11. For purposes of control over equipment produced (prototype and mass models), engineering agencies and producing plants designing and producing noisy equipment must be supplied with measurement and control apparatus (sound gages, as well as filters or other types of analyzers).

Requirements for the Reduction of Noise at Operator Posts in Planning, Remodeling and Building Industrial Sites and Scientific Research Facilities

12. In planning and remodeling industrial structures in which noisy machines are to be installed, measures must be taken to ensure:

(a) the reduction of noise at operator posts to permissible levels;

(b) the prevention of the propagation of loud noise outside of the premises on which the noise-producing machines are operating, to neighboring areas or beyond the limits of the building.

13. To reduce noise at operator posts and in the locale where noise-producing machines are installed, it is necessary to:

(a) concentrate the more noisy units, operating at a noise level in excess of the permissible standard at the operator post, at one or more points of the shop, and insulate them by means of casings or shields ensuring the required reduction in noise; however, the sound-insulating devices must allow for remote operation and control of the machine.

If production conditions preclude the sound-insulation of noisy plant units, it is required to provide operating personnel with soundproof cabins, with observation windows and lead-ins for remote control equipment and instruments. The cabins must be provided with doors and windows acting as effective sound insulators. Inside, the cabin must be lined with sound-absorbing materials;

(b) in noisy production locales of relatively small size (to 400-500 cubic meters), line ceiling and part of the walls (no less than 50 percent of their surface) with sound-absorbing material, such as acoustic plaster, porous acoustic tile, perforated materials, etc. Such linings will lower noise level inside the locale by 5 - 8 db.

In larger locales, such linings are ineffective.

(c) line the outside of metal supply lines, carrying parts and waste materials, such as, for example, compressed air conveyers, with materials that absorb vibrations (rubber, bituminous materials, etc.)

14. To prevent the propagation of loud noise from noisy locales to quiet ones or beyond the limits of the building, the following considerations should be used for guidance:

(a) the choice of a construction site for industrial plants and scientific research institutes operating with noisy equipment must be selected with reference to the existing or planned lay-out of the town or industrial center;

(b) industrial plants and scientific research institutes operating with equipment responsible for a level of noise exceeding 90 db should be located on the leeward side of the nearest residential area (in terms of prevailing wind direction), and should be separated from the residential area by a buffer zone, in accordance with calculations shown in Appendix 5. The acoustical buffer zone must be landscaped and planted with bushy-leaved or coniferous trees;

(c) beyond the boundaries of the buffer zone, the total level of noise originating from the plant or institute must not exceed 50 phon.;

(d) in planning the lay-out of a plant, the noisier installations should be grouped at one or two points removed at some distance from office buildings (see Appendix 5).

If the plant is located within city limits, noisy installations should be situated in interior portions of the plant area, i.e., as far away as possible from residential buildings adjoining the site;

(e) noisy installations should be surrounded with a buffer zone, planted with bushes, bushy-leaved or coniferous trees;

(f) the sound-insulating materials shielding noisy installations must dampen sound propagated outside of these installations to the extent of inhibiting its propagation to other buildings and neighboring locales, and of not increasing the level of noise already present in them by more than 3 db (in accordance with Appendix 5);

(g) to dampen "frame" or "shock" noise propagated to neighboring areas through the frame of the building, all units generating vibrations (motors, power units, ventilators, etc.) must be mounted on individual foundations, insulated from the floor and other structural elements of the building, or on specially designed shock-absorbers, consisting of steel springs or other elastic elements.

The stiff mounting of such units directly on the enclosing structural elements of the building is prohibited.

To inhibit the transmission of vibrations and noise through air ducts and pipe lines, their juncture to ventilators and pumps must be effected by means of flexible insets of rubberized fabric or rubber junctions;

(h) the outlets of air ducts performing suction and discharge operations for the more powerful plant units and ventilators and leading out of the building must be equipped with mufflers that reduce noise to levels provided for under Sub (f) of the present Para;

(i) installations responsible for noise of particular intensity, exceeding the 130 db level, and having unobstructed exhausts, must be located outside of city limits, at a distance of several kilometers (as determined from calculations) from the nearest residential area, and on the leeward side of it, in terms of predominant wind direction.

15. To reduce noise produced by conveyances within the plant, the following regulations must be observed:

(a) rail tracks must be laid on an elastic foundation that will not conduct vibrations, and joints must be welded;

(b) main roads inside the plant area must be surfaced with asphalt, and the sides of the roads must be planted with trees.

Requirements for the Reduction of Noise at Operator Posts at Industrial Sites and Scientific Research Facilities in Operation

16. In all industrial locales, where noise levels at operator posts exceed established standards, measures must be taken to reduce noise to permissible levels, to the extent that this can be accomplished by means of relatively simple means, which do not require extensive remodelling of the entire installation.

In this connection, the following measures are obligatory:

(a) noisy plant units and components thereof, insofar as possible, must be insulated in separate compartments and casings;

(b) vibrating and noise-generating surfaces of units and parts (abrasion-polishing drums of ball mills, guide pipes of automatic turret lathes, etc.) should be lined with materials that dampen vibrations;

(c) metal parts (gears, etc.) should be replaced by plastic ones;

(d) interior surfaces of premises (of a volume exceeding 400 cubic meters) should be lined with sound-absorbing materials;

(e) operating personnel should be provided with cabins insulated for sound;

(f) for high frequency noises, such as, for example, noises produced by installations ejecting high-velocity air streams, operators should be protected by means of shields or screens lined with sound-absorbing materials;

(g) additional insulation should be used in rooms adjacent to sources of noise;

(h) vibrating plant units should be mounted on elastic shock-absorbers to inhibit the propagation of sound to adjoining locales;

(i) exhaust and intake openings should be provided with mufflers.

17. All units in operation should be subject to regular inspection with the object of timely correction of all defects that may lead to added noise (worn gears, bearings, couplings, incorrect assembly and mounting of parts, infrequent or insufficient lubrication, etc.)

Appendix 1

BASIC DEFINITIONS AND CONVENTIONAL DESIGNATIONS

1. The harmfulness of noise is determined, in the main, by its intensity, its frequency composition (spectrum), its duration, and its continuity.

   High-frequency noises, i.e., noises in which high-frequency sounds predominate, are more harmful than low-frequency noises. For this reason, permissible levels of noise intensity are established relative to the frequency composition of the noise.

2. The level β of the intensity of sound or noise J is measured in logarithmic units termed decibels (db) and indicates how many times the magnitude of J exceeds initial sound intensity J_0. The point of departure is arbitrarily taken to be $J_0 = 10^{-9}$ erg/cm^2 sec. or 10^{-16} watts/cm^2. This value corresponds to the threshold of hearing (i.e., to a barely audible sound) for a tone of 1000 hz*. The level of the intensity of sound is determined from the formula:

$$\beta = 10 \log \frac{J}{J_0} \quad \text{db} \qquad (1)$$

   Differences in levels, i.e., the reduction of sound or noise, are also measured in decibels.

3. The level of loudness L of a noise or sound of a given frequency is the level β of the intensity of a 1000 hz tone equal in loudness to the ear to the given noise or sound; the unit of measurement of the level of loudness of a noise or sound is called the phone.

   A variation in loudness of 1 phone is perceived by the ear as a barely noticeable one. Variations in level of loudness of 8 - 10 phones are perceived by the ear as a doubling of the loudness of the sound.

   For sounds of a frequency of 1000 hz, decibels and phones are equal numerically. This is also approximately true for loud sounds (when level β exceeds 80 db) and for noises chiefly composed of sounds within the 400 to 5000 hz frequency range.

4. Interference from weak low-frequency noises at 50 to 60 db is determined, mainly, by their level of loudness.

   The measurement of the frequency spectrum of such noises is technically difficult with usual instruments. For this reason, for such plant locales as administrative, clerical and engineering offices, permissible levels of loudness (L_p) are established in phones, regardless of frequency spectrum characteristics.

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* The hertz (hz) is a unit of frequency, equal to one oscillation per second.

Noise intensity and loudness levels are measured by means of calibrated noise gages with an accuracy of ± 1 db (phone).

5. The total noise level from N sources at a point equidistant from them is determined from the following formula (see Table 2):

$$\beta = \beta_1 + 10 \log N \ldots \text{ db} \qquad (2)$$

where β_1 is the level of noise from one source, and N is the number of sources of the noise.

Table 2

Number of sources of noise	1	2	3	4	5	6	8	10	20	30	40	100
Increment to level of one source 10 log N	0	3	5	6	7	8	9	10	13	15	16	20

For the combined effect of two distinct sources of levels β_1 and β_2, total level β equals:

$$\beta = \beta_1 + \Delta\beta \quad \ldots \text{ db} \qquad (3)$$

where β_1 is the larger of the two levels that are added, and $\Delta\beta$ is the increment, as determined from Table 3.

For several different sources of noise, additions in accordance with formula (3) are performed in series.

Table 3

Difference of levels of two sources $\beta_1 - \beta_2$ db	0	1	2.5	4	6	10
Value $\Delta\beta$, to be added to the higher level (β_1) db	3	2.5	2	1.5	1	0.5

If the difference in levels between two sources exceeds 6 - 8 db, it is permissible to disregard the level of the less powerful sources relative to the more powerful one.

Noise decreases with removal from the source. For this reason, when several sources of noise of equal magnitude occur in a large enclosed area, the noise of each source predominates in its own vicinity; the increment from more distant sources is small and usually does not exceed 3 - 5 db.

6. The spectrum or frequency composition of a noise reveals the relative distribution of the sonic energy of noise throughout the range of sonic frequencies. The spectrum curve makes it possible to determine the range within which occurs the major portion of sonic energy contained in a given noise.

For example, it is apparent from Fig. 1 that, in the noise spectrum represented by the broken line, most of the sonic energy occurs in the 350 to 1600 hz frequency range.

Appendix 2

METHODS OF NOISE MEASUREMENT

1. The measurement of the total level of intensity of noise in decibels (for levels exceeding 75 db) must be performed by means of a calibrated noise gage, with the frequency characteristics switch set at "horizontal characteristic".

   Note. In making measurements with automatic frequency characteristic settings (such as the LIOT noise gage), the frequency characteristics switch should be set at the "decibels" position.

2. The measurement of the total level of loudness of noise in phones (for levels below 75 db) must be performed with the frequency characteristics switch of the noise gage set at the following positions:

   (a) "40 phones" for measurements of levels from 25 phones to 55 phones;

   (b) "70 phones" for measurements of levels from 55 phones to 75 phones.

   Note. In measurements by means of noise gages with automatic frequency characteristic settings, the frequency characteristics switch should be set at the "phones" position.

3. Determinations of the frequency composition (spectrum) of a noise must be made with a calibrated noise gage, coupled to an octave band filter, equipped with an output indicator graduated in decibels.

   It is recommended to use filters whose filtering band width is under an octave*, i.e., equals 1/2 or 1/3 of an octave. It is also permitted to use an analyzer of constant relative filtering band width.

4. The measurement of the spectrum of a noise is carried out in the following manner:

   (a) the frequency characteristics switch of the calibrated noise gage is set at the "horizontal" (or "decibels") position;

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* An octave is a frequency interval in which the upper frequency limit is twice the lower one.

(b) the levels switch is set at such a position as to result in a dial reading of the measured noise that will be significant in terms of the scale of the instrument;

(c) the systematic switching of filtering bands then allows the determination of relative noise levels in each of the bands from readings of the output indicator. The highest of these levels is then arbitrarily taken as zero decibels (see Figs. 1 and 2). Level values in other bands of the spectrum will then indicate the degree to which these levels fall below the maximum in decibels;

(d) values determined for relative noise levels in various bands of the spectrum are expressed as ratios of the mean geometric frequencies f_m of these bands.

$$f_m = \sqrt{f_1 \cdot f_2}$$

where f_1 and f_2 are, respectively, the lower and upper frequencies passing through the filter.

Mean geometric frequency values for octave filters are given in Table 4.

Note. These values have been rounded out for greater convenience in use.

Table 4

Filtering Bands and Mean Geometric Frequencies of Octave Filters

Band No.	Frequency Ranges in Octave Band, Hz	Mean Geom. Fqcies, Hz	Frequency Ranges in Octave Band, Hz	Mean Geom. Fqcies, Hz
1	37.5 - 75	50	50 - 100	75
2	75 - 150	100	100 - 200	150
3	150 - 300	200	200 - 400	300
4	300 - 600	400	400 - 800	600
5	600 - 1200	800	800 - 1600	1200
6	1200 - 2400	1600	1600 - 3200	2400
7	2400 - 4800	3200	3200 - 6400	4800
8	4800 - 9600	6400	6400 - 12800	9600

5. Measuring equipment must be checked annually at the All-Union Institute of Meteorology (or by some other organization within the Committee of Standards, Measures and Measuring Instruments) and certified.

6. Results of measurements must incorporate corrections as required by the characteristics of the measuring circuit as a whole, including noise gage and filter.

7. Noise measurement must be carried out at operator posts and:

   (a) at two points along the long axis of the room, at distances of 1/3 from the transverse walls and at a height of 1.5 meters, in shops where noisy equipment is evenly distributed;

   (b) at a distance of 1 m from the plant unit, on the side of the source of noise and at a height of 1.5 meters from the floor, in shops where noisy units are grouped together;

   (c) in the center of the enclosed area, at a height of 1.5 meters from the floor, for observation cubicles and rooms which do not contain noise-producing equipment;

   (d) at duct openings, from which noise is propagated into the free air:

   - at a distance of 1 m from the edge of the duct opening, in the plane of the cross section of the duct;

   - at four points around the building from the duct issues, at a distance of 10 m from the walls and at a height of 1.5 meters from the ground.

8. In quiet plant locales, where noise level does not exceed 75 db, measurements need be made only of the level of loudness in phones (see Para 2 of Appendix 2), unaccompanied by noise spectrum determinations.

Appendix 3

DETERMINATION OF PERMISSIBLE LEVEL OF NOISE FROM GRAPH OF STANDARDS (Fig. 1)

1. Measure total level of noise intensity in decibels by means of calibrated noise gage (see Para 1 of Appendix 2).

2. Measure frequency spectrum of noise in decibels, by means of noise gage and coupled filter (see Paras 3 and 4 of Appendix 2).

3. Plot noise spectrum (Fig. 2) from data of measurements on a form of identical scale to that of graph of standards (Fig. 1), for which purpose:

   (a) plot mean geometric filter frequencies on the abscissa (see Para 4, sub (d) of Appendix 2);

   (b) plot measured values of noise levels in various bands below the zero decibel point on the ordinate axis, at points corresponding to mean geometric frequency values (see examples 1 and 2 in Fig. 2). Take the highest of the measured levels in the spectrum as equalling zero decibels (see Para 4, sub (c), Appendix 2). In other words, plot differences in decibels between maximum levels in the spectrum and other levels in various bands of spectrum on the ordinate.

4. Superimpose transparent print of graph of standards (Fig. 1) on the noise spectrum graph thus obtained, by aligning the coordinate axes of both graphs*.

Noise is to be considered permissible when the line delimiting the noise spectrum does not fall outside of the curve of standards (Fig. 1), corresponding to total measured noise intensity level, by more than 3 db.

Example 1

Total noise level measured by noise gage β = 84 db. Noise spectrum, measured by octave filter:

Mean Geometric Fqcies of Octave Bands, Hz	50	100	200	400	800	1600	3200	6400
Readings of Output Indicator of Filter, β_f db	5	4	1	0	3	3	15	17

We then plot noise spectrum on millimeter paper or on a special form (Fig. 2, Curve 1). By superimposing the coordinate axes of the form with those of the graph of standards, we find that at all frequencies, except that of 1600 hz, the curve outlining the measured noise spectrum falls below the standard curve for noise at levels up to 85 db. At the 1600 hz frequency, the curve of the spectrum lies 2 db above the permissible value, a difference that is within the margin allowed (see Para 4 of this appendix). Therefore, noise is within permissible values.

Example 2

Total noise level measured by noise gage β = 80 db. Noise spectrum measured by octave filter:

Mean Geometric Fqcies of Octave Bands, Hz	50	100	200	400	800	1600	3200	6400
Readings of Output Indicator of Filter, β_f db	30	21	19	18	14	16	0	4

We plot noise spectrum on a form (Fig. 2, Curve 2). By aligning the coordinate axes of the form with those of the graph of standards, we find that at frequencies of 3200 and 6400 hz, the curve outlining the measured noise spectrum falls above permissible values for noises at levels up to 80 db by 5 db. Therefore, noise exceeds permissible values.

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* The graph of standards may be plotted on ordinary paper, in which case the two superimposed graphs should be held up against the light.

Appendix 4

TESTING INTELLIGIBILITY OF SPEECH UNDER NOISY CONDITIONS

Under given conditions of noise, an announcer (or an individual with good elocution) reads numbers of several (four or five) digits in a voice of normal loudness. Four or five listeners record these numbers at a distance of 1.5 meters from the announcer. If, of the 50 numbers read, over 40 are recorded correctly, intelligibility is taken to be satisfactory, and the noise is considered not to exceed permissible standards.

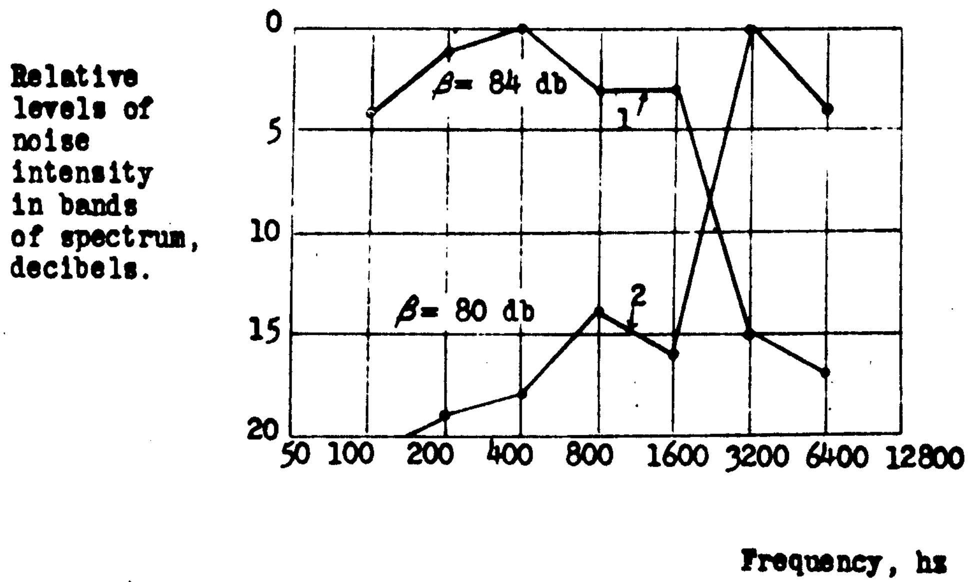

Fig. 2. 1 - Permissible noise (total level = 84 db);
2 - Noise above permissible level (total level = 80 db).

Appendix 5

Instructions for the Selection of Sound-Proofing Devices, for the Sound-Insulation of Enclosing Structural Elements, and for the Efficient Planning of Plant Sites.

1. The data needed for the design of sound-proof casings or mufflers may be obtained from the formulas given below.

   The needed quantity δ, expressing the reduction of noise required to attain permissible level β_p at the operator post, equals:

$$\delta = \beta_n - \beta_p + 5 \ \ldots \ \text{db} \qquad (4)$$

where β_n is the noise level of the unshielded source at the operator post.

Approximate values for β_n for various sources of noise are given in Table 6. For greater accuracy, it is advisable to determine values for β_n through direct measurement.

Noise reduction effected by a casing, all of whose parts are sound-conducting roughly to the same degree, may be calculated by means of the following formula:

$$\delta = I + 10 \log \alpha \qquad (5)$$

where I is the natural sound-insulation of the walls of the casing in decibels, and α is the mean coefficient of sound absorption of the inner surfaces of the casing.

The quantity α for various materials may be found in tables*, while values for I are determined from the formula:

$$I = 13.5 \log P + 13 \ \ldots \ \text{db} \qquad (6)$$

where P is the weight of one square meter of casing wall in kg/m. sq.

The data needed (coefficient of sound-absorption of the inner lining and the weight, that serves to determine the material and thickness of the casing walls) are obtained by calculation from formulas (4), (5) and (6).

Noise reduction obtained through the interior lining of ducts through which noise is propagated outside of the casing is determined from the following formula:

$$\delta = 1.1 \frac{\alpha P}{S} 1 \text{ db} \qquad (7)$$

where α is the mean coefficient of sound-absorption of the material used as inner lining in the duct, P is the circumference of the cross-section of the duct (in meters), S is the surface of that cross-section, and 1 is the length of the lined portion of the duct (in meters).

2. In selecting sound-insulating materials for enclosing structural elements, Appendix 8 of "Health Standards for Planning Industrial Sites" H 101-54 should be used as a guide. β_n levels of noise in various industrial locales used in calculations should be taken from Table 6 of Appendix 6. 60 db should be taken as permissible level of noise β_p for quiet locales situated on the plant premises (in accordance with Para 5 of Section A of the Standards).

3. The planning of the location of industrial structures on the premises of a plant must be such that noise reaching the outside from noise-producing locales does not increase the noise levels in other buildings by more than 3 db.

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* See table on pp 229-232 in the book by I.I. Slavin entitled "Industrial Noise and How to Fight It", Profizdat, 1955.

To satisfy this requirement, it is necessary to: (1) calculate the insulation needed in enclosing structural elements (see Paras 1 and 2 of this Appendix); and (2) determine the distances which must separate noisy locales from less noisy ones.

To decrease interference through noise, buildings containing noisy locales should be so oriented in relation to buildings containing less noisy locales that the windows of these buildings do not face on one another.

The distance r (in meters) at which sources of noise must be removed from buildings containing less noisy locales, as well as the degree of sound insulation I (in decibels) for a given distance, may be determined from the following formulas:

(a) when the buildings to be insulated from sound are located at a distance up to 100 meters from the source of noise, and when a number of buildings are located in that area (within a radius of 100 meters from the source):

$$\log r = \frac{\beta_n - \beta_p - I}{15} \tag{8}$$

(b) when the buildings to be insulated from sound are located at a distance greater than 100 meters and in open areas:

$$\log r = \frac{\beta_n - \beta_p - I}{20} \tag{9}$$

In these formulas:

β_n is the noise level at the source, in db;
β_p is the permissible noise level in a quiet locale, in db;
I is the sound-insulation effectiveness, in db, of elements shielding the noise source or insulating a locale from sound.

Values for I for some of the more frequent cases, which do not require special measures in the way of sound insulation, are given in Table 5.

Note. When calculation by means of formula (8), for given values of β_n, β_p, and I yields values r_1 that exceed 100 meters, while calculation by formula (9), for equal given values, yields values r_2 that are below 100 meters, the final value of r is taken to be their mean geometric value as determined by both formulas, i.e.

$$r = \sqrt{r_1 \cdot r_2} \text{ meters}$$

Table 5

No.	Location of the Noise Source Relative to the Locale to be Insulated	I in db
1.	Unobstructed source of noise (exhaust pipes, units operating in the open air):	
	(a) the locale to be insulated has open windows facing toward the noise source	0
	(b) the locale to be insulated has open windows facing away from noise source	10-15*
2.	The source of noise is located inside a building:	
	(a) the locale to be insulated has open wondows facing toward the noise source	10
	(b) the locale to be insulated has open windows facing away from noise source	20-30*

Example

Problem: Determine the minimum distance r at which it is possible to locate a laboratory building (permissible level of noise 50 phones or $\beta_p = 60$ db) from a building which contains a pneumatic riveting shop. The noise level in the shop $\beta_n = 115$ db. The windows of the shop in which the noise is generated face in a direction opposite to that of the laboratory.

We find from Table 5 that the value of I in this case equals 20.

We first proceed to use formula (8):

$$\log r_1 = \frac{115-60-20}{15} = 2.34$$

or, $r_1 = 220$ meters.

Since the value of r_1 was found to exceed 100 meters, we repeat the calculation by means of formula (9):

$$\log r_2 = \frac{115-60-20}{20} = 1.75$$

or $r_2 = 56$ meters.

Since the value for r_2 obtained by means of formula (9) was found to be below 100 meters, the final value of r will be the geometric mean of the two values calculated (see Note to Para 3):

$$r = \sqrt{220.56} = 110 \text{ meters.}$$

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* Depending on the height of the buildings.

Table 6 — Appendix 6

Levels and Descriptions** of Industrial Noises

1: Sources of Noise	2: Level of noise, in db	3: Description of noise
1. Noises from industrial machines		
a) Turbulent		
1. Engine-testing sites	130 - 140	Low-frequency
2. Centrifugal blowers of various models	80 - 105	Low- and median-frequency
3. Compressed air power units with mufflers	90 - 95	-
4. Pneumatic polishing and drilling machines	100 - 105	Tonal, high timbre
5. Pneumatic rolling machines	105 - 110	High-frequency exhaust noise
6. Cupola furnace	95 - 98	Low-frequency
7. Compressor installation VKS-6	110	High-frequency hissing
b) Mechanical		
8. Pneumatic sheet metal riveting machine	110 - 115	High-frequency
9. Hand riveting machine	105 - 110	High-frequency
10. Shaving of weld seam by pneumatic chisel	115 - 120	"
11. Cutting of boiler seam by electric cutting mill	108 - 110	"
12. Stamping with compressed-air tool	98 - 105	"
13. Pneumatic molding machine	114	"
14. Air hammer	105	Low-frequency
15. Bolt press (plant Imeni Molotov)	105	High-frequency
16. Nut blanking press (plant Imeni Molotov)	95	"
17. Nail making machine	95 - 105	"
18. Abrasion-polishing drums of ball mills	100 - 110	"
19. Same as item 18, sound-proofed by LIOT method	86 - 92	Low- and median-frequency
20. Cement-grinding mill of Unidan model	108	High-frequency
21. Crude ore and coal mills	98	Low- and median-frequency

** High- median- and low-frequency noises are those in which predominate sounds in the ranges below 350 hz, 350-800 hz and above 800 hz, respectively.

1: Sources of Noise	2: Level of noise, in db	3: Description of noise
22. Fat-liquoring drums for leather processing	97	Gear noise
23. Tanning drum	89	"
24. Spreading machine for leather dressing	103 - 105	Tonal, pulsating
25. Shoe blanking machines	100 - 102	Blows
26. Shoe tightening machines	98 - 100	-
27. Cutting mill for cutting out soles	95	-
28. Automatic revolving mills	92 - 94	Ringing median- and high-frequency
29. Same, with noiseless LIOT tube	84 - 86	Duller than item 28
30. Lathes	85 - 93	Median-frequency
31. Rotating printing machines	95	Gear noise
32. Braiding and plaiting machines ("Sevkabel'" plant)	90	High-frequency
33. "Platt" loom	104	"
34. Scutching unit	105	"
35. Bar-loom	80	Low-frequency
36. Speeder	95	High-frequency
37. Shredder	85	Low-frequency
38. Spinning mill on the side of the driving gear	105	Median- and high-frequency gear noise
39. Plush-making mill	105	-
40. Cookie stamping machine	103	High-frequency
41. Mechanical shears	100	-
42. Pneumatic conveyors	93 - 105	Median-frequency
43. Typewriter on soft mat	68 - 70	-
44. Typewriter directly on desk	74	-
45. Powerful electric motors	85 - 100	Tonal, low-frequency
46. Low-power electric motors of enclosed type	40 - 60	-
47. Ship steam engines	90	Low-frequency
48. Ship diesel engines	100 - 115	High-frequency
49. Car gasoline engine (measured under hood)	80 - 90	Median-frequency
50. Rough grinding of mirror glass on cast-iron grinding wheel	108	High-frequency
51. Sawing vinyl sheets by cutting disk or on lathe	106	"
52. Sawing vinyl pipes of square cross-section by circular saw	108	Tonal, high-frequency
53. Same, as in item 52, when pipe cross-section is round	116	Same
54. Wire drawing	95	-

1: Sources of Noise	2: Level of noise, in db	3: Description of noise
2. Noise in Shops		
55. Nail-making	98	High-frequency
56. Bolt-pressing, cold-riveting	96	"
57. Boiler-making	100 - 105	"
58. Braiding and plaiting in cable plants (700 machines)	100 - 102	High- and median-frequency
59. Weaving (220 looms)	105 - 110	Same
60. Scutching	105	Median- and high-frequency
61. Sorting-scutching in a spinning and weaving plant	83	Low-frequency
62. Carding	78 - 80	"
63. Speeding	95	High-frequency
64. Spinning	90 - 100	Median- and high-frequency gear noise
65. Knitting	94	-
66. Sowing	85	-
67. Cloth cutting	75	-
68. Cottonizer (in hosiery manufacture)	90	-
69. Dough-mixing (in bakeries)	80	-
70. Lumber mill	96 - 100	-
71. Rubber mill (rolling)	90 - 92	-
72. Calculating machine room	95	Median- and high-frequency
73. Telegraph control room	86 - 90	Same
74. Typing pool (no sound-proofing)	70 - 78	"
75. Typing pool, with sound-absorbing lining	68 - 74	Duller than item 74
76. Type-setting room	97	High-frequency
77. Machine room of electric power plant	95	Low-frequency
78. Turbo-compressor room	118	"

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